NDCEE

National Defense Center for Energy and Environment

Zero Energy Homes for Military Installations

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Presentation Overview

- Project Objective And Drivers
- Project Evolution (Phase I and II)
- Project Team and Approach
- Design Approach
- Energy Modeling Results
- Path Forward

OBJECTIVE: Help the DoD build cost-effective, energy-efficient housing. As a step towards achieving this, the NDCEE is assisting with the design and evaluation of the performance of ZEH for military installations.

Project Drivers

- In FY06, 300,000 DoD homes used 11 trillion BTUs of electricity at a cost of $254M
- Military Housing Privatization Initiative of 1996 provides opportunity for private expertise/capital to be used for military housing (DoD is privatizing 195,000 homes by 2010)
- Executive Order 13423, Energy Policy Act of 2005, and Army policy require more energy-efficient/less polluting buildings
- Energy efficiency leads to reduced electricity use and costs, increased energy security, supply stability, reduced greenhouse gases, and improved living environment
- Work is transferable across all Services and into the private sector

Project Overview

- Use integrated design and energy modeling to demonstrate zero energy housing
- Validate the potential to provide cost effective zero energy housing
- Transfer project knowledge DOD-wide and beyond

ESTCP Project Team

Stakeholders

Environmental Security Technology Certification Program (ESTCP)
US Army Installation Management Command Southeast (IMCOM SE)

Team Members

National Defense Center for Energy and Environment (NDCEE)
Fort Campbell
Fort Campbell Family Housing (FCFH)
Actus Lend Lease
Pacific Northwest National Laboratory (PNNL)
National Association of Home Builders Research Center (NAHB-RC)
7- Group
Luckett and Farley

Project Approach

- Design
  - Establish Approach and Methods
  - Delineate Constraints
  - Establish Baseline
  - Establish Initial Energy Efficiency Design
  - Model Charrette Technologies
  - Final Design
- Construction
- Monitoring
- Technology Transfer

Design Approach and Methods

- Held design team teleconferences to begin to:
  - identify constraints/baseline conditions
  - set performance goals
  - identify specific technologies, tools, and strategies.
- Held two-day design charrette with multi-disciple, multi-organizational team
- Tools used:
  - Integrated Design: Replaces the traditional sequential design process by integrating multiple disciplines early in the process to help identify and optimize systems and reduce overall costs
  - Energy modeling and analysis
  - Life-cycle cost analysis

Constraints

- Street exterior to be unaltered
- Baseline and ZEH to be placed in existing development plan
- Occupants historically not responsible for utilities
- Work within existing floor plan

Baseline Design

- Duplex
- Four-bedroom
- Two-story dwelling
- 1,985 square feet of conditioned space per unit
- 2.5 baths
- Energy Star Rating

Photo courtesy of Luckett & Farley; Architect of Record.

Pre-Charrette Recommendations

- Ground-source heat pumps
- High R-values: R25 walls, R49 ceiling, R30 over garage, R10 slab
- Energy Star appliances
- Hard-wired lighting 100% fluorescent
- Low air leakage, ventilation air heat recovery
- Solar water heater
- Other considerations:
  - More southern windows
  - Ceiling fans
  - Reduced misc. loads
  - Solar clothes dryers (clothes lines)

Design Charrette: August 25-26, 2008

- FCFH
  - Luckett and Farley Architects
  - Construction staff
  - Maintenance staff
  - Cost estimator
  - HVAC contractor
- ESTCP
  - NDCEE
  - 7 Group
  - PNNL
  - NAHB
  - IMCOM-SE

Major Design Element Changes: Envelope

- Insulation
  - 2x6 Walls – R19 + R5 sheathing
  - Floor over garage – R30
  - Attic – R60
- Sealing
  - Wall and cavity
  - Top plates
- Windows
  - Max U-value 0.31
  - Max SHGC 0.32

Major Design Element Changes: Hot Water (87% decrease)

- Centralized tank
- Manifold distribution
- Solar thermal preheat - 64-80 ft^2 collector
- 120 gallon storage tank with 4,500 W element

Major Design Element Changes: Appliances

- High efficiency
  - Clothes washer – 66% decrease
  - Dishwasher – 72% decrease
  - Exhaust fans
- No change
  - Clothes dryer
  - Range
  - Refrigerator

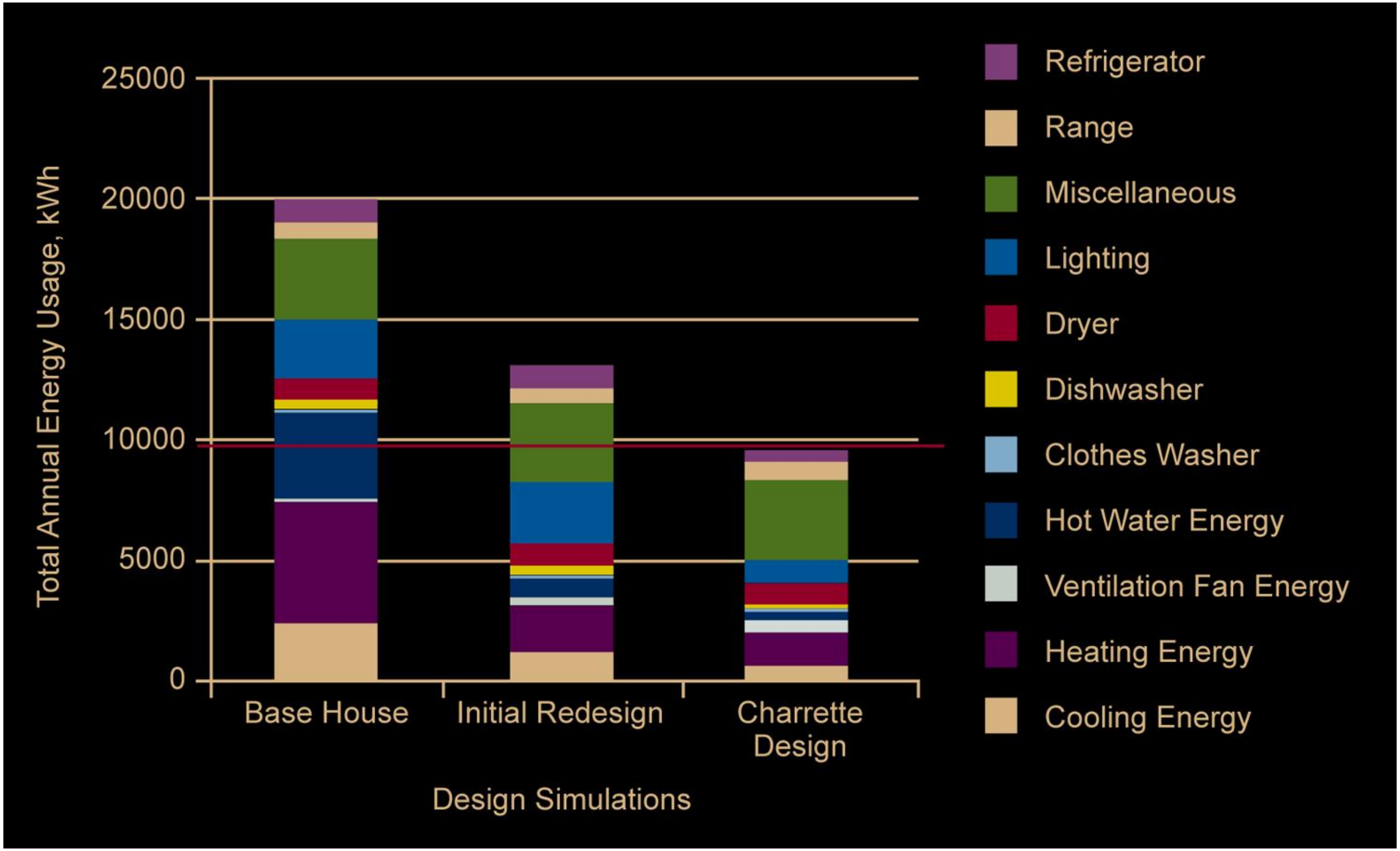
Major Design Element Changes: HVAC

- Ground Source Heat Pump
  - 18 EER and 4.0 COP
- Ducts
  - Sealed
  - Insulated

Modeled Demand Reductions

- Total Electric Demand 54%
  - Heating/Cooling/Hot Water 75%
  - Appliances and Lights 23%

Modeling Results



Design Lessons Learned

- Up front energy modeling beneficial to assess alternatives
- Iterative energy modeling during design is useful to assess effect of changes
- There's no substitute for having all parties engaged: designers, maintainers, constructors, vendors, users
- Occupant behavior has large and growing impact on success

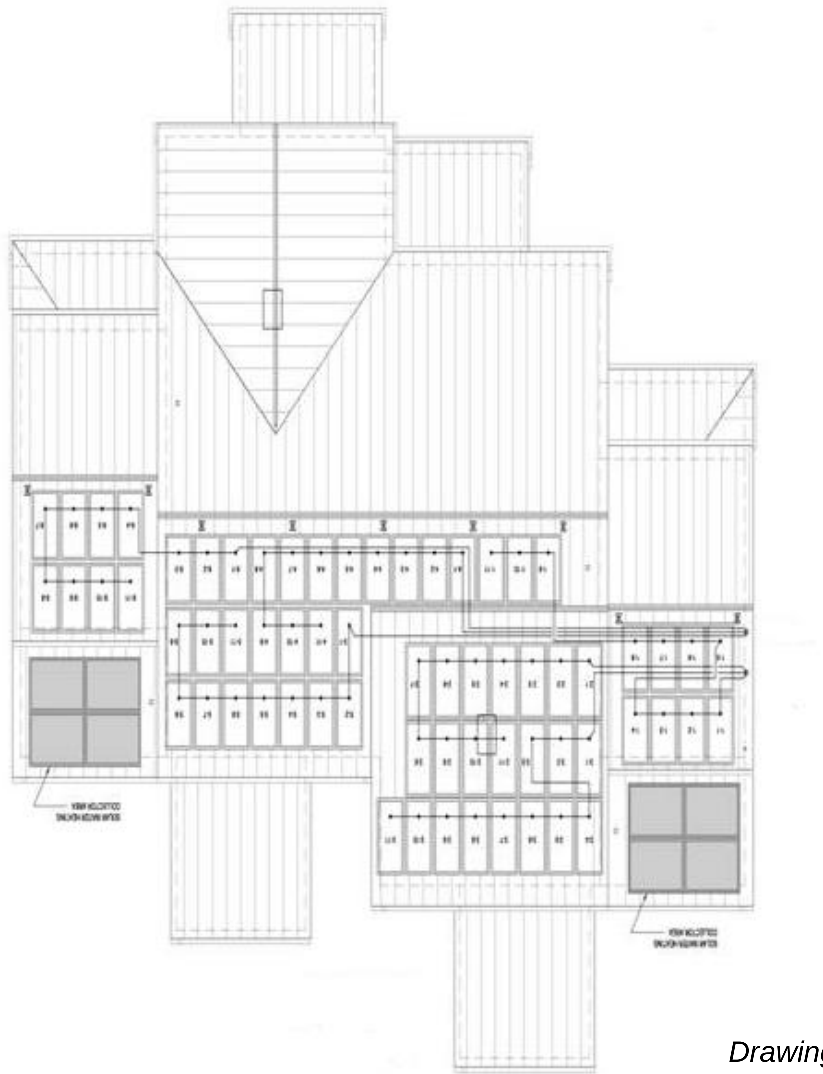
Initial Exterior Design

Redesign of South facing roof provides space for solar water heating and photovoltaics

Replace gables and hip with shed; added porch roofs

Final Roof Design with PV Array

- 6 Strings of 11 panels in series
- 33 – 225 W panels per unit
- 7,425 W per unit
- 14,850 W total



Drawing Courtesy of Luckett and Farley

Cost Implications

- Early modeling
  - 7% increase in first costs for energy demand reduction
  - 25% increase in first costs for renewables
  - Payback 25-30 years
- 98% design snapshot
  - Still being evaluated

Measuring Success: Initial ZEH Performance Objectives

- Reduce design energy demand
  - 50% less than current duplex demand of 34.8 kbtu/sf
  - 60% less than national average demand of 46.7 kbtu/sf
- Reduce modeled net energy use of design to zero
- Reduce water consumption per capita by 30%
- Reduce measured energy consumption
  - Whole building – 50%
  - HVAC – 60%
  - Domestic hot water – 60%
  - Lighting – 10%
  - Plug loads – 10%
  - Appliances – 20%
- Reduce estimate air emissions, including CO_2
- Achieve measured energy generation @ 80% of design intent
- Maintenance – no cost/manpower increase
- Occupant satisfaction – higher for ZEH

Measuring Success: Occupants are the Key

- 3,337 kWh/year plug loads – 35% of remaining demand
- Our approach
  - Willing volunteers
  - Monitoring equipment in living space
  - Education program
  - Monthly feedback and support from research team
  - Occupant comfort surveys

Measuring Success: From Demonstration to SOP

- FCFH and Actus Lend Lease are considering using the following technologies in all new construction:
  - Ground source heap pumps
  - All compact fluorescent lighting
  - High efficiency appliances

Next Steps

- Construction and Monitoring
  - Includes occupant education program
  - Commissioning
- Performance Validation
  - Energy consumption, cost, and use patterns
  - Environmental impacts
  - On-site energy production
  - Maintenance costs and labor-hours
  - Occupant comfort and satisfaction
  - Lifecycle cost, net present value, simple payback

Final Steps

- Technology Transfer
  - Present results at energy and construction industry conferences
  - Produce case study
  - Develop ESTCP reports
  - Incorporate lessons learned into over 40,000 military housing units that Actus Lend Lease is building nationwide

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